Article

Rapid Food Hygiene Inspection Tool (RFHiT) to assess hygiene conformance index (CI) of street food vendors

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Abstract

Street-vended food is a popular choice among consumers as they are cheap, convenient and easily accessible, especially in Asia. Studies have assessed street food vendors' food safety and microbiological quality of street-vended foods and overall findings revealed gaps and inconsistencies in hygiene practices. High numbers of street food vendors vs low numbers of environmental health officers and limited time remains a challenge in most developing countries in assessing the hygiene compliance of food services. Most inspections rely on paper-based assessments of the cleanliness and hygiene practices of staff. This study developed a Rapid Food Hygiene Inspection Tool (RFHiT) to assess and calculate the hygiene conformance index (CI) of 95 street food vendors. RFHiT allows rapid assessment as it takes less than 20 minutes to assess each street food vendor. 51.30% of the street food vendors were rated as moderately clean whilst 14.25% were rated as poor and 0.95% as very poor. 20% of the vendors achieved a good rating with six street-food vendors rated as excellent. The proposed tool further demonstrated practical implications of using the rapid inspection tool to assess actual hygienic practices of street food vendors, thus reducing the Hawthorne effect among food handlers.

Keywords: conformance index; food handlers; food safety; hygiene; premises; preparation

Highlights

- A new tool for rapid hygiene assessment of street food vendors is proposed.
- Allow rapid and discrete assessment of hygiene compliance among street food vendors.
- Calculation of conformance index (CI) and CI_{REL} allow critical comparison and prioritisation of resources.

Introduction

WHO (2015) estimated that a total of 600 million of foodborne diseases worldwide resulted in more than 400,000 deaths in 2010. The main causes of foodborne disease were attributed to diarrhoeal disease agents especially norovirus and *Campylobacter* spp. Diarrhoeal disease agents that caused the highest number of deaths were non-typhoidal *Salmonella enterica*. Other major causes of foodborne deaths were *Salmonella typhi*, *Taenia solium*, hepatitis A virus and aflatoxin (WHO, 2015). Foodborne diseases arises from the contamination of food by microbiological contamination, naturally produced toxins or chemicals (van Seventer, & Hamer, 2017). Foodborne diseases in South East Asia is largely caused by unhygienic practices. Street food vendors and schools were found to be common settings for foodborne outbreaks to take place (Dewanti-Hariyadi, & Gitapratiwi, 2014). In Malaysia, the five most significant pathogens isolated from stool samples of diarrhoeal patients were nontyphoid *Salmonella*, enteropathogenic *Escherichia coli*, *Shigella*, *Campylobacter* and *Aeromonas* (Dewanti-Hariyadi & Gitapratiwi, 2014). Studies reported that up to 55% (n=187) of the investigated *Salmonella* isolates from vegetables and processing environment (Abatcha, Effarizah, & Rusul, 2018), 99% (n=114) of *Salmonella* from poultry and processing environment (Chuah, Syuhada, Suhaimi, Hanim, & Rusul, 2018) and 54% of *Campylobacter* isolates (n=59) in cattle and beef meat (Premarathne et al., 2017) were multi-drug resistant. Recent studies by Woh et al. (2017) revealed that non-typhoidal *Salmonella* exist among migrant food handlers. Some of the *Salmonella* isolates were found to be multi-drug resistant against ampicillin, chloramphenicol, trimethoprim-sulfamethoxazole, sulphonamides, streptomycin and tetracycline. This poses food safety and health risks to consumers through food contamination.

In Malaysia, the main contributing factor to foodborne diseases were identified as unsanitary food handling practices which accounted for more than 50% of the reported food poisoning incidents (Soon, Singh, & Baines, 2011). Street food vending in Malaysia generates a multi-million US dollar trade providing direct employment to vendors and food handlers (Alimi, 2016; Shafiee, Ab Karim, Mohamed Razali, & Ungku Zainal Abidin, 2017). Street foods are described as ready-to-eat food and beverages that are prepared and sold by vendors in public places. The stalls are often located outdoors, or under a roof which is easily accessible from the street (Winarno & Allain, 1991) and are often vended from mobile or stationary stalls. Street foods are attractive to consumers due to its

location, accessibility and affordable prices. The vendors are often found in major street corners, construction sites, bus or train terminals, fresh food or wet markets, night markets, nearby schools or other major business centres. However, the environment in which the food is prepared and sold are exposed to potential contamination (Alimi, 2016). Study by Leong et al. (2010), revealed that although tourists were very satistfied with food prices, flavours, variety and availability of food whilst travelling in Malaysia, there were concerns about the sanitation and hygiene level of food stalls in Malaysia. Unhygienic and/or contaminated street food could be potential source of foodborne diseases. Travellers often develop acute diarrhoea during their stays in tropical and subtropical regions (Sanders, Riddle, Taylor, & DuPont, 2019). For example, von Sonnerburg et al. (2000) reported that two of three tourists developed traveller's diarrhoea whilst vacationing in high risk destinations. Enterotoxigenic *E. coli*, *Campylobacter jejuni* and other bacterial enteropathogens were the most common cause of acute diarrhoea (Sanders et al., 2019).

A number of food safety studies among street food vendors had been conducted globally. In Kolkata, India, 71% of street food vendors operate in contaminated areas, 57% had no dustbin facilities and 67% had no access to nearby toilet facilities (Ghatak & Chatterjee, in press). In Vietnam, food vendors were found to have poor food safety knowledge and attitude levels and operate under largely unhygienic environments (Samapundo, Cam Thanh, Xhaferi, & Devlieghere, 2016). Similarly, street food vendors in Haiti were found to operate under unhygienic conditions although they exhibited average food safety and attitude levels (Samapundo, Climat, Xhaferi, & Devlieghere, 2015). Trafialek et al. (2018) conducted a comparative study of food hygiene practices in Asia and EU and found many non-compliances in hygienic practices, although the surveyed EU country showed higher conformity in food hygiene practices than in Asian countries. Most studies assessed street food vendors and food handlers' self-reported food hygiene practices. Few studies utilised an inspection tool to assess the level of hygiene compliance among food services. The vast number of street food vendors that need to be inspected by environmental health officers or food safety inspectors remain a challenge in developing countries. Trafialek, Drosinos and Kolanowski (2017) developed a fast observation questionnaire to assess street food vendors' hygienic practices while Santana, Almeida, Ferreira and Almeida (2009) calculated the hygiene compliance of catering facilities using a checklist.

In addition to assessing individual street food vendors, there is currently no tool that assess and compare the hygiene conformance of street food vendors. This study aims to develop a Rapid Food Hygiene Inspection Tool (RFHiT) to assess and calculate the hygiene conformance index of street food vendors.

Methodology

Rapid Food Hygiene Inspection Tool (RFHiT)

The items in RFHiT is designed to assess the compliance of hygienic requirements of street food vendors (Table 1). It is divided into five parts: Part 1: Premises and food preparation area (17 questions); Part 2: Preparation (5 questions); Part 3: Storage (6 questions); Part 4: Serving (4 questions) and Part 5: Hygiene practices (12 questions). The questions were developed primarily based on Food Hygiene Regulations (2009). The Regulations aim to control the hygiene and safety of food sold in the country to protect public health and consist of seven main sections including: Part I – Preliminary (e.g. definition of terminologies e.g. potable water, sanitary); Part II – Registration of food premises; Part III – Conduct and maintenance of food premises (e.g. location, design, water supply, cleanliness, pest control, disposal); Part IV – Food handler (e.g. personal hygiene); Part V – Special requirements in handling specifif food (e.g. meat, fish, ice); Part VI – Carriage of food (e.g. cleanliness, separation of food from non-food item) and Part VII – Miscellaneous (e.g. penalty) (Food Act 1983 [Act 281], 2012). The questions were largely derived from Food Hygiene Regulations Part III to Part VI, Santana et al. (2009), Trafialek et al. (2017) and Trafialek et al. (2018). Food hygiene items that were deemed more likely to result in cross contamination of food and increased public health risks were awarded two points. Criteria for the definition of each food hygiene scoring was based on review of literature (Santana et al. 2009; Trafialek et al. 2018) and Food Hygiene Regulations (2009).

Insert Table 1 here

The food hygiene items from Table 1 were adapted into Bristol Online Survey (BOS) system which allows observation to be carried out using a smartphone. Factor analysis using a varimax rotation was

conducted to establish construct validity (DeVon et al., 2007; Gu et al., 2018). Construct validity is the extent to which the instrument (in this case – RFHiT) measures the construct it is intended to measure (DeVon et al., 2007). Construct validity was selected as it evaluates the appropriateness of an instrument for a specific purpose (i.e. hygiene assessment) and to determine the level of confidence one can place on the assessment scores using RFHiT (Streiner et al., 2015). The Kaiser-Meyer-Olkin (KMO) value of more than 0.60 and factor loading of 0.40 and above indicates adequate relationshiop of each item in the underlying factor (Hair et al., 2009). RFHiT was pilot-tested at three street food vendors and open street restaurant at both peak (12 – 2pm) and non-peak hours (3 – 5pm). After pilot-testing RFHiT, it was noted that street food vendors have different ideas of pest-deterring techniques, reliance on ice-boxes and some stalls provided limited eating are. Hence additional questions i.e. 1.6 (Did you observe other forms of pest deterring devices?), 3.3 (Ice box is used) and 4.4 (Customer serving / eating area (tables, chairs, floor) are kept clean) were added. Six research assistants well versed in food safety management systems were trained. All users learnt to apply the observation method and to use RFHiT. The validation method was based on the World Health Organization hand hygiene observation method (Sax et al., 2009; Stewardson et al., 2013). Before conducting the hygiene observation session, the users were validated by the principal investigator. All six users engaged in the hygiene observation session at two street food vendors and completed the hygiene assessment. Results were then reviewed, compared and discordant notifications were discussed (Sax et al., 2009). The intra-class coefficient was calculated to determine the inter-rater reliability (ICC). ICC estimate was calculated using SPSS version 25.0 based on 2-way mixed effects model and consistency. Values less than 0.5 indicate poor reliability, 0.5 – 0.75 indicate moderate reliability, 0.75 and 0.9 indicate good reliability and values greater than 0.90 indicate excellent reliability (Koo, & Li, 2016).

Street food vendors were selected at random in eight cities and towns throughout Peninsular Malaysia including Kota Bharu in Kelantan, Johor Bahru in Johor, Kota Melaka in Melaka, Butterworth and Georgetown, Penang (31), Ipoh and Tronoh in Perak (16) and Kajang, Selangor (15) and were evaluated using the Rapid Food Hygiene Inspection Tool. The street food vendors included in this study are street restaurants (open restaurants located in permanent premises and situated next to

146 traffic and are easily accessible by public), street food booths or kiosks (food stalls with minimal
147 facilities and could be re-located easily), mobile food cart or food truck (food stalls operated from a
148 motorised vehicle / bicycle / pushcart), night market stall (similar to mobile food carts or trucks but
149 only operate at night in specific locations) and wet market stall (food booths located within a market
150 place with shared facilities such as public toilets and waste collection).
151
152 **Compliance with hygienic requirements**
153 The street-food vendors' food hygiene compliance were calculated using the formula below. The
154 formula was modified from Santana et al. (2009) .
155
156 $$P = \left(\frac{TS}{\Sigma_1 - \Sigma_2}\right) \times K$$
157
158 Where P = Part 1 to 5 (Part 1: Premises and preparation area, P2: Preparation, P3: Storing, P4:
159 Serving, P5: Hygiene);
160 TS = Total score;
161 Σ_1= Total possible points;
162 Σ_2= Total non-applicable points;
163 K = constant, where *K* values for P1 = 38.41; P2 = 11.69; P3 = 16.70; P4 = 6.64 and P5 = 26.72
164 ($\sum K$= 100) (The logic for calculation K values can be provided upon request)
165
166 Formula 1. Calculation of food hygiene compliance
167
168 The total score is the score obtained for a specific area of assessment e.g. Premises and Preparation
169 area. In Σ_1, the total possible points are – Part 1: Premises and preparation area = 23; P2:
170 Preparation = 7; P3: Storing = 10; P4: Serving = 4 and P5: Hygiene = 16. The non-applicable points
171 (Σ_2) are equal to the points awarded for 'yes' and are deducted from the total possible points to
172 remove potential confounding factors that may arise from calculating non-existing variables. For
173 example, sections related to food preparation will be noted as not applicable if a street food vendor

does not have a food preparation area and only sells wrapped, ready-to-eat foods directly. This is to avoid distortion of the final hygiene score. The mean score of the five parts was calculated as: (P1+P2+P3+P4+P5/10) and the street food vendors were classified according to a scale: 0 – 1.9 (very poor: urgent improvement necessary); 2.0 – 4.9 (poor: major improvement necessary); 5.0 – 6.9 (moderate; some improvement required); 7.0 – 8.9 (good) and 9.0 – 10.0 (excellent).

Calculation of conformance index formula

A conformance index formula was adapted from Dzwolak (2016) to compare the total conformance index % of the street food vendors. This formula is useful to compare conformance % according to location, type of facilities, number of employees or food hygiene requirements.

$$CI = \left(\frac{\Sigma_{i=1}^{n} Es \times N_{SFV_i}}{AMES_{N_{SFV}}} \right) \times 100$$

Where, CI = Conformance index (%)

Es: Evaluation score;

N_{SFV}: number of street food vendors;

AMES: Adjusted maximal evaluation score (calculated as number of food stalls x maximal evaluation score [10]. Note that the number of food stalls is dynamic and is adjusted according to the number of assessments. Meanwhile the maximul evaluation score is fixed at 10).

Formula 2. Calculation of conformance index (CI)

The CI is then converted into relative state which range from 0 – 1 using the following formula:

$$CI_{REL} = \frac{CI_{cur} - CI_{min}}{CI_{max} - CI_{min}}$$

Where CI_{REL} = relative state of CI (between 0 – 1);

CI_{cur} = current CI under evaluation;

CI_{min}= minimum value of CI

CI_{max}= maximum value of CI

Formula 3. Calculation of relative conformance index (CI_{REL})

Results

Exploratory factor analysis was carried out to test the construct validity. The Kaiser-Meyer-Olkin (KMO) measure of sampling value for was 0.66. This fulfills Hair et al. (2010) who stated that the criterion of validity should be > 0.60, indicating the principal component analysis (PCA) was appropriate. PCA was performed using varimax rotation. All factor loadings were > 0.40 and explained 45.46% of the total variance. A high degree of reliability was found between the hygiene observations among the users. The average ICC measure was 0.89, $F(1, 5) = 9.90$, $p < 0.05$).

Ninety five street food vendors were evaluated using the Rapid Food Hygiene Inspection Tool (RFHiT). Street food vendors located in major cities or towns in six states in Peninsular Malaysia i.e. Johor (n = 19), Kelantan (n=11), Melaka (n=3), Penang (31), Perak (16) and Selangor (15) were randomly selected and observed. Each street food vendor was evaluated for an average of 17 minutes. Table 2 shows the characteristics of the street-vended food stalls. Street restaurants, night market stalls and street food booths represent the top three types of food stalls observed in the study. Most of the food stalls were operated by two food handlers and sold freshly prepared meals, ready to eat meals and beverages. More than half (57%) of the street food vendors were located near to traffic (57%) or heavy traffic (20%), open drains (33.25%) and rubbish collection point (16.15%).

Insert Table 2 here

The individual hygiene scores for all street food vendors are shown in Supplementary data. 30.5% of the food stalls were either located under a tree, bridge, under public stairways or walkways. 20.9% of

food stalls used Ultra Violet (UV) fly traps to catch insects. Street restaurants (11) were the most frequent users as their outlets were permanent and could easily install a UV trap in their restaurant. Food stalls that do not use UV fly traps used other forms of pest deterring devices ranging from plastic bags filled with grease to trap insects, lit candles, portable fan, fly swatter, glue trap and polyethylene film to cover food products. 31.4% of the premises have access to toilet facilities. Of this, 66.67% were observed to be visually clean, not smelly and contain running water. 60.61% of the facilities provided adequate soap or foam for handwashing. 45.6% of the food stalls do not have access to running water.

14.74% of the food stalls were observed to use equipment such as knives and chopping boards for both raw and cooked food. During food preparation, raw food came into direct contact with cooked food in 3.80% of the food stalls. 57.95% of the food stalls immediately prepared and served or sold food according to order. This helps to ensure foods are served warm or cold depending on type of food or beverages sold. Storage capacity is limited among street food vendors. This is evident by the lack of cold storage facilities where only 20.90% had a chiller and/or freezer to store their food products. Forty eight stalls used iceboxes for cold storage. Although foods were prepared and served on visually clean utensils or packaging materials, 52.25% of the food stalls did not store the cutleries, plates or packaging materials appropriately and are prone to contamination.

Four food handlers were observed to be eating or chewing gum whilst preparing food while nine of the street food vendors were smoking. One food handler was observed to have visible cuts on his/her hands. 72.2% of the street food vendors had short, clean and unpainted nails and 49.40% did not wear any jewelleries including watches. Less than half of the food handlers (42.75%) were found to wear caps or hair covers (including turbans / headscarves). Of those wearing hair covers, 82.22% covered their hair fully. Street food vendors were also found to keep their clothes clean and presentable (77.90%) and 57.95% wore clean aprons whilst handling food. An estimated 26% of the street food vendors touched their face, nose, ears or hair whilst handling food and 20% were found to use their bare hands to handle unwrapped ready-to-eat food. Only 33.25% were observed to wash their hands after handling items such as raw food, dustbin and cash.

Insert Figure 1 here

51.30% of the street food vendors were rated as moderately clean whilst 14.25% were rated as poor and 0.95% as very poor. 20% of the vendors achieved a good rating with six street-food vendors rated as excellent (Figure 1).

Conformance index

Results of calculation of the Conformance Index % are shown in Table 3. Street food vendors in Selangor demonstrated the highest compliance for the evaluation criterion under analysis. Wet market stalls and street restaurants represented the facilities with higher rate of conformance compared to other types of street food vending facilities. Calculations of the relative values of CI_{REL} are presented in Figure 2. The radar charts allow one to visualise the size of the areas of compliance. There were variations between different regions e.g. ranging from CI_{rel} 0 in Perak to CI_{REL} 1 in Selangor.

Insert Table 3 here

Insert Figure 2 here

Discussion

The rapid assessment conducted in this study demonstrated that street food vendors' overall hygiene compliance were moderate and required improvement. This study reiterates previous studies where street food vendors' hygienic practices were not satisfactory (Muyanja, Nayiga, & Nasinyama, 2011; Samapundo et al., 2015; Trafialek et al., 2018). A number of street food vendors were often located near traffic and other areas e.g. open drains, rubbish collection point, building or construction sites and / or even near toilet facilities. This poses a problem as food products are constantly exposed to

potential contamination from the open environment, e.g. dust, smoke from motorised vehicles, pests and physical contamination especially if the street food vendor is located under walkways / stairways / bridge. A number of open street restaurants in Malaysia are within vicinity of open drains and pests including stray dogs and cats could easily access the premises. Street food vendors may prefer to select location with easy access to high number of customers, despite the fact that the location may not be as hygienic or easy to maintain good hygienic practices. Interviews conducted by Pang and Toh (2008) revealed that hawkers preferred to work on the roadside than being relocated to a designated site due to better business and less competitors on the roadside.

The lack of running water facility and reliance on bottled water may discourage food handlers from washing their hands and utensils. Food stalls that used buckets of water may re-use the water to wash their hands, utensils and raw materials. This poses the risk of contamination via the re-used water. Contaminated water is a vehicle for foodborne pathogens such as *E. coli, Salmonella* spp. and *Campylobacter* spp (Rane, 2011). The lack of adequate supply of potable water remains one of the most critical problem among street food vendors (Dawson, & Canet, 1991; Rane, 2011). In Mankee et al. (2003), the authors found street food products that came from vendors with no water supply at their food stalls had significantly higher number of unfit samples compared to vendors with water supply. The lack of toilet facilities is another cause for concern. This may also impact on food handlers' handwashing practices due to the lack of facilities and time (e.g. street food vendors may need to walk or search for the nearest public toilet).

Street food vendors are categorised as micro or small food businesses and operate with minimal capital and resources including storage capacity. Although some of the food vendors utilised ice boxes, this warrants further investigation – particularly in terms of segregating raw and ready to eat food in different, labelled ice boxes. Malaysia is a tropical country with average temperature ranging from 27°C to 33°C (Climate-data, n.d.). The hot and humid weather is an attractive factor for street food vendors especially those selling cold desserts and beverages but the warm weather is conducive to bacterial foodborne pathogens such as *Escherichia coli, Salmonella* spp., *Staphylococcus aureus* and *Vibrio* spp. (Bryan, 2004). This was evident in previous studies where multi-drug resistant

316 *Klebsiella pneumonia* were isolated in 32% of street foods (n=78) (Haryani et al., 2007) and 35% of
317 fresh vegetables / salad (n=43) purchased from wet market stalls in Malaysia were positive for
318 *Salmonella* (Salleh et al., 2003). Al Mamun, Rahman and Turin (2013) reported unsatisfactory
319 coliform levels in 44% of food samples (n=110) collected from school-based street food vendors
320 while foodborne pathogens including *Escherichia coli, Staphylococcus aureus, Listeria*
321 *monocytogenes, Shigella* and *Enterobacteriaceae* were found in street vended ready-to-eat meats
322 (Shiningeni, Chimwamurombe, Shilangale, & Misihairabgwi, 2019). Poor personal hygiene especially
323 the lack of handwashing after handling dirty items were observed in this study. Previous studies
324 reported 46% (Liu, Zhang, & Zhang, 2014) and 76% (Ghatak, & Chatterjee, 2018) of street food
325 vendors did not wash their hands after handling contaminated materials. Woh et al. (2017) isolated
326 non-typhoidal *Salmonella* and multi-drug resistant *Salmonella* from migrant food handlers in Malaysia
327 (Woh et al., 2017). Unsatisfactory personal hygiene may cross contaminate food products with
328 foodborne pathogens leading to potential foodborne illnesses.
329
330 Selangor was ranked highest in hygiene compliance compared to other states. A number of factors
331 could affect the ranking e.g. number of food hygiene inspections carried out by the local authorities,
332 food handlers' knowledge and attitude, food safety training and education, and consumer's demands.
333 This study was conducted in July and August of 2018 and coincided with the nation's food safety
334 incident where food handlers in a street restaurant in Selangor were filmed washing dishes in a
335 puddle of dirty water by the roadside (NST, 2018). The film was shared on social media over
336 YouTube, blogs, Twitter, Whatsapp and online news. It went viral and garnered more than 300,000
337 views and 750 comments. Comments i.e. 'boycott the restaurant', 'ban', 'hygiene', 'health authorities'
338 and 'inspection' were commonly expressed by the online community (YouTube, 2018). Ultimately, the
339 restaurant was shut down by local health authorities for unhygienic practices (The Star Online, 2018).
340 It is possible that street food vendors were aware of the food safety news and consumers demand
341 stricter food safety inspections from the local authorities. The unfortunate incident may have
342 increased food handlers' awareness and attitudes towards food hygiene and safety. The variations
343 between different regions could potentially be due to ineffectiveness of food safety strategies of local
344 control authorities (Pang, & Toh, 2008). Although the street food vendors found the food safety

guidelines clear and understandable, the guidelines were deemed impractical and this potentially discourages the hawkers adherence to food safety guidelines (Pang & Toh, 2008). Pang and Toh (2008) also reported that socio-demographic factors i.e. ethnicity, religion and education of food handlers may affect the implementation of food safety strategies.

The type of street food vending facilities influenced the level of conformity with hygienic requirements. Wet market stalls were found to have the highest level of compliance followed by street restaurants. Having access to appropriate hygiene facilities increase the level of hygiene compliance by wet market stalls and street restaurants. Traditional wet markets in Malaysia are typically open food market where floors are routinely washed. Wet markets sell live animals, fresh fish, fresh produce and food products. A number of disease outbreaks are commonly transmitted through food and live animals in markets. The World Health Organization (2006) introduced the Healthy Food Markets to improve the safety of foods sold in urban markets. One of the key recommendations were the improvements in physical infrastructure e.g. provision of sufficient toilet and handwashing facilities, adequate potable water supply, proper drainage and regular waste disposal from closed containers and zoning of areas to prevent cross contamination. To date, wet market stalls in Malaysia are undergoing urban renewal process and relocated to hygienic building areas (Md Sharif, Md Nor, Mohd Zaharia, & Muhammad, 2015). Street restaurants are located in permanent buildings with access to chilled and/or frozen storage, water supply, toilet facilities and kitchen sinks. Trafialek et al. (2018) reported street restaurants tend to have the highest conformity due to the appropriate social facilities and restaurant management.

RFHiT allows rapid assessment as it takes less than 20 minutes to assess each street food vendor. In standard food safety inspections, it was found that hawkers "only wear hats to show the authorities when they come to check" (Pang & Toh, 2008). Using RFHiT on a smartphone enables discrete observation of street food vendors and allow inspectors to assess the actual hygienic practices of food handlers, effectively reducing the Hawthorne effect (change in behaviour) among food handlers. Direct observation may result in workers changing their behaviour when they know that they were being observed and can result in falsely elevated compliance rates (Haas & Larson, 2007). Training of

food inspectors and/or assessors in observation methods and use of RFHiT must be carried out to ensure validity and reliability. As a start, inspectors could carry out the assessment with a trained observer at a number of sites and the results are then compared and any discordant notifications could be discussed. The ICC value for test-retest reliability or inter-rater reliability should be more than 0.75 to achieve good consistency. Calculation of compliance scores and CI_{REL} allows one to rate the food hygiene compliance and visualise the size of the areas of compliance according to location, type of facilities or number of employees (not calculated here). There is also potential to compare the historical data and evaluate if hygiene improvements were made over the years. Further enhancement to RFHiT could be made to enable food inspectors to show street food vendors which area of assessments could be further improved. Resources such as food handlers' training and food safety awareness programme, provision of designated and hygiene facilities could potentially be provided to areas that require urgent improvement to ensure food hygiene practices and reduction in foodborne illnesses.

Although RFHiT allows rapid assessment of the hygienic practices of street food vendors, this could be potentially be a limitation as the rapid assessment only observe the hygiene practices of the street food vendors for a small window of time. Although RFHiT is easy to use, food inspectors must be trained to ensure rigorous and consistent assessment and interpretation of hygiene compliance rate. There is a total of 43 questions in the tool to cover the essential inspections especially cleanliness and hygiene practices of the food handlers. Some food safety inspectors may find using the tool as an additional burden on top of the existing, food safety and hygiene inspections. However, this tool os not to replace current, existing legal compliance checks but is a rapid, starting point for further inspections. The findings in this study should be not be generalised as the hygiene conformance indexes are calculated for the specific street food vendors.

Conclusion

This study proposed a new rapid food hygiene assessment tool to determine the level of hygiene conformance among street food vendors. Assessment of street food vendors revealed food hygiene gaps and provides the data necessary for the improvement of regulations and policies. Street food

vendors are often located near traffic and other less hygienic areas including open drains, rubbish collection point, building or construction sites and / or even near toilet facilities. This poses a problem as food products are constantly exposed to potential contamination from the open environment. The findings clearly show that provision of appropriate hygiene facilities and infrastructure can help to improve food hygiene practices. The proposed tool further demonstrated practical implications of using the rapid assessment tool to assess actual hygienic practices of food handlers, effectively reducing the Hawthorne effect among food handlers.

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588 Table 1. Street-food vendors' food hygiene items in Rapid Food Hygiene Inspection Tool

No.	Items in RFHiT	Yes	No	Not applicable (N/A)*
			(Scores)	
1	**Premises**			
1.1	Shop / stall is protected from sun, wind and dust	1	0	1
1.2	Shop / stall area is located in clean area (e.g. not situated near rubbish area, heavy traffic, large opened drains)	1	0	1
1.3	Shop / stall is NOT located under a tree, bridge, stairs, walkway or other unhygienic areas	1	0	1
1.4	Shop / stall area is maintained in a clean condition	1	0	1
1.5	Is there a working fly trap visible in the work place?	1	0	1
1.6	Did you observe other forms of pest deterring devices?	1	0	1

No.	Items in RFHiT	Yes	No	Not applicable (N/A)*
1.7	Is the premise generally free from pests e.g. insects (apart from the insects trapped in the fly trap) animals, rodents, pets?	2	0	2
1.8	Are there toilet facilities for staff?	2	0	2
1.9	Toilet facilities are clean, not smelly and with running water	2	0	2
1.10	Adequate soap or foam provided	2	0	2
	Food preparation area			
1.11	Food preparation / cooking area is constructed of materials that are easy to clean and smooth	1	0	1
1.12	Food preparation area is kept in clean and good order	2	0	2
1.13	There is supply of clean, running water	2	0	2
1.14	Handwashing facilities are available nearby	1	0	1
1.15	Food stalls do not re-use water in buckets	1	0	1
1.16	Utensils and dishes are washed in kitchen sink	1	0	1
1.17	Utensils and dishes are NOT stored and accumulated in basin	1	0	1
2.0	**Preparation**			
2.1	Cooking appliances / utensils are maintained in good condition and clean	1	0	1
2.2	Separate equipment such as knives and cutting boards are used for handling raw food	2	0	2
2.3	Food is prepared and served immediately	2	0	2
2.4	During food preparation, raw / fresh food is not in direct contact with cooked food	1	0	1

No.	Items in RFHiT	Yes	No	Not applicable (N/A)*
2.5	Separate utensils (e.g. chopping boards, tongs, chopsticks) are used to serve cooked foods	1	0	1
3.0	**Storage**			
3.1	Raw or fresh foods are stored separately from ready to eat food	2	0	2
3.2	A fridge or freezer is used to store food	2	0	2
3.3	Ice box is used	1	0	1
3.4	Food is stored / displayed in a covered container	1	0	1
3.5	Food is kept hot if the food is to be served hot (N/A if food is prepared and served immediately)	2	0	2
3.6	Food is kept cooled if the food is to be served chilled (N/A if food is prepared and served immediately)	2	0	2
4.0	**Serving**			
4.1	Food is served with clean and safe packaging materials (e.g. no newspaper in direct contact with food)	1	0	1
4.2	Food is served with clean utensils / plates	1	0	1
4.3	Utensils / plates / packaging materials are stored and protected against contamination	1	0	1
4.4	Customer serving / eating area (tables, chairs, floor) are kept clean (N/A if no eating area is provided)	1	0	1
5.0	**Hygiene**			
5.1	Cook / staff does not eat or chew gum whilst handling food	1	0	1

No.	Items in RFHiT	Yes	No	Not applicable (N/A)*
5.2	Cook / staff does not smoke whilst handling food	1	0	1
5.3	Cook / staff has no visible cuts or visible skin diseases symptoms on hands uncovered by gloves	2	0	2
5.4	Cook / staff has short, clean (and not painted) nails	2	0	2
5.5	Cook / staff wears caps / hair covers (including headscarf / turban)	1	0	1
5.6	Hats or hair covers effectively prevent hair from falling into food	1	0	1
5.7	Cook / staff does not wear jewelleries, watches, pins or other accessories	1	0	1
5.8	Cook / staff does not touch face, nose, ears or hair whilst handling food	1	0	1
5.9	Cook / staff does not use bare hands to handle unwrapped ready to eat food	2	0	2
5.10	Cook / staff's clothes are clean and presentable	1	0	1
5.11	Cook /staff uses a clean apron when handling food	1	0	1
5.12	Cook / staff wash or clean hands after handling unclean items e.g. raw food, money, dustbin etc	2	0	2
	Total score	60		

589 *Note that the non-applicable points are deducted from the total possible points to remove potential confounding
590 factors and avoid distortion in the final hygiene score.
591

592 Table 2. Characteristics of street-vended food stalls (n=95)

Items	Frequency (%)
Type of facilities	
Street restaurant (exposed to opened environment)	27 (25.7)

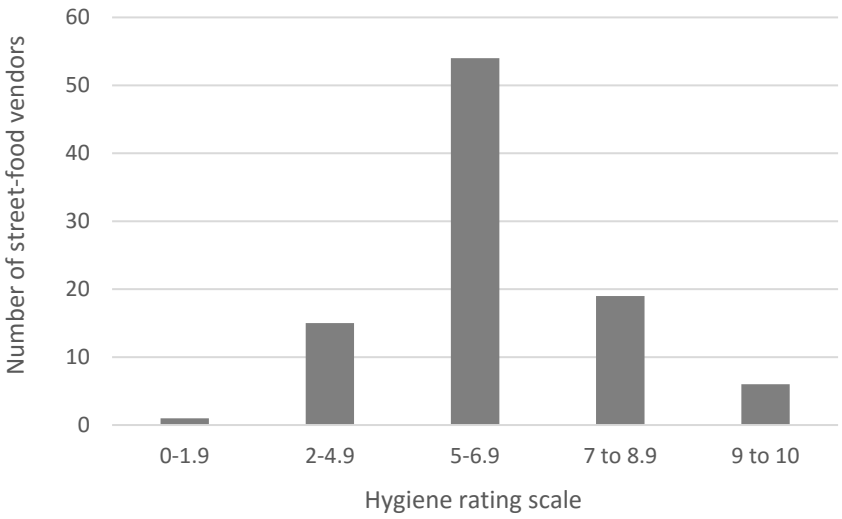
Items	Frequency (%)
Street food booth / kiosk	24 (22.8)
Mobile food cart / food truck	8 (7.6)
Night market stall	26 (24.7)
Wet market stall	3 (2.9)
Others	7 (6.7)
Number of employees	
One	16 (15.2)
Two	41 (39.0)
Three	15 (14.3)
Four or more	23 (21.9)
*Type of food sold	
Freshly prepared meals (e.g. noodles, chapatti, burgers)	42
Ready meals (e.g. economy rice, nasi lemak, prepared noodles)	32
Savoury food (e.g. steamed buns, glutinous rice)	25
Desserts (cakes, confectionaries, ice kacang [Malaysian shaved ice dessert], cendol [sweet, iced dessert])	24
Beverages	31
Fruits and vegetables	14
Others	7
*Location or point of sale is near:	
Heavy traffic (next to main roads)	21
Traffic (next to roads with occasional traffic)	60
Opened drains	35
Rubbish collection point / skip	17

Items	Frequency (%)
Toilet facilities	7
Building site or construction area	8
Others	14

*Street food vendors sold more than one type of food and were exposed to one or more areas prone to contamination

Table 3. Conformance index according to states and type of facilities

States	Conformance index %
Johor	64.56
Kelantan	64.35
Melaka	65.77
Penang	59.85
Perak	50.44
Selangor	76.94
Facilities	
Street restaurant	70.60
Street food booth / kiosk	52.61
Mobile food cart / food truck	58.54
Night market stall	58.99
Wet market stall	83.27
Others	65.83



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600 Figure 1. Hygiene ratings of observed street food vendors (n=95). Note: 0 – 1.9 (very poor [urgent
601 improvement necessary]); 2.0 – 4.9 (poor [major improvement necessary]); 5.0 – 6.9 (moderate
602 [some improvement required]); 7.0 – 8.9 (good) and 9.0 – 10.0 (excellent).
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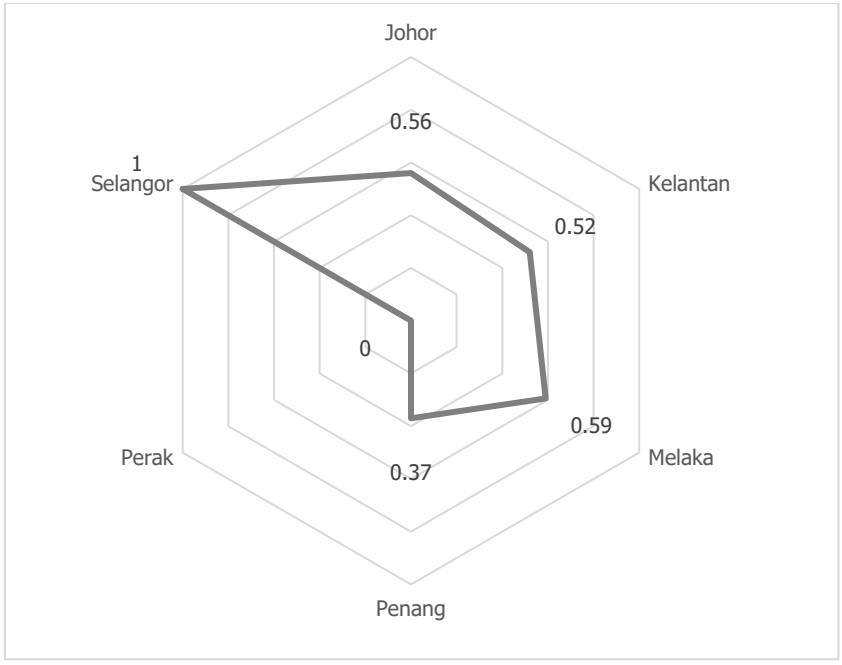

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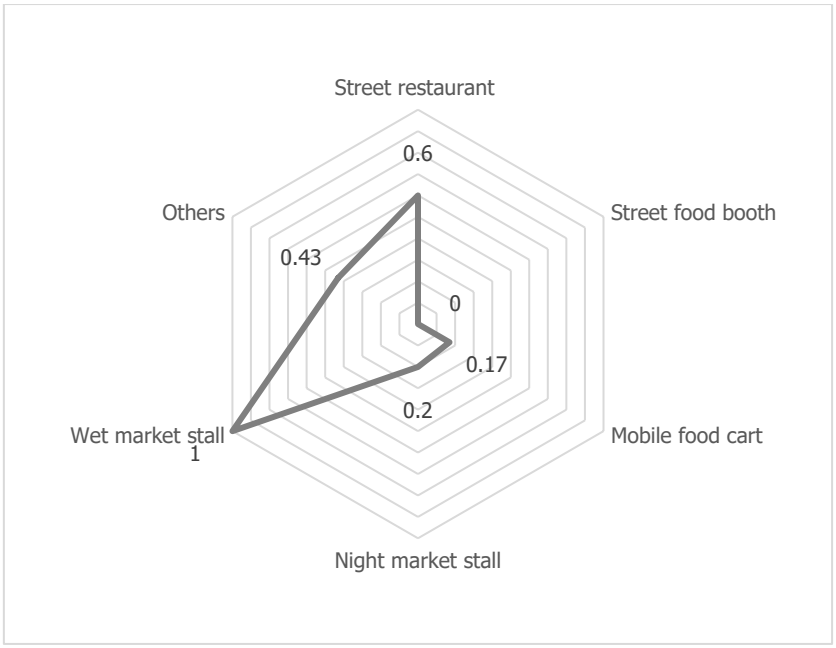
606 (a)

607



(b)

Figure 2. CI_{REL} of street food vendors according to (a) states and (b) type of street food vending facilities (n=95)

Supplementary data

Table 1. Total score for P1 – P5 (Part 1: Premise, P2: Preparation, P3: Storing, P4: Serving, P5: Hygiene) and hygiene rating of observed street food vendors (n=95)

Part	Part 1	Part 2	Part 3	Part 4	Part 5	Total score / 10
J1	20.95	8.35	14.61	5.01	15.03	6.40
J2	15.03	11.69	8.35	5.01	18.37	5.85
J3	6.06	11.69	8.35	4.45	18.37	4.89
J4	11.30	11.69	8.35	6.68	26.72	6.47
J5	6.98	5.01	5.01	6.68	15.03	3.87
J6	14.15	6.68	3.71	3.34	20.04	4.79
J7	21.34	11.69	10.44	6.68	21.71	7.19
J8	9.04	8.35	4.18	4.45	25.05	5.11
J9	25.05	11.69	11.13	6.68	21.71	7.63
J10	15.82	11.69	5.57	6.68	26.72	6.65
J11	20.33	3.90	16.70	6.68	26.72	7.43
J12	33.40	11.69	11.13	6.68	25.05	8.80

Part	Part 1	Part 2	Part 3	Part 4	Part 5	Total score / 10
J13	35.07	11.69	13.92	6.68	26.72	9.41
J14	20.33	11.69	11.13	6.68	26.72	7.66
J15	18.08	11.69	5.57	6.68	23.38	6.54
J16	11.30	11.69	8.35	6.68	23.38	6.14
J17	14.94	11.69	8.35	6.68	21.71	6.34
J18	13.56	11.69	5.57	6.68	20.04	5.75
J19	13.56	8.35	5.57	6.68	23.38	5.75
					Total score	122.67
K1	26.72	10.02	15.03	1.67	10.02	6.35
K2	34.37	11.69	13.36	6.68	26.72	9.28
K3	23.64	8.35	11.13	5.01	15.03	6.32
K4	18.19	11.69	14.61	5.01	16.70	6.62
K5	20.22	8.35	13.92	5.01	15.03	6.25
K6	12.80	11.69	0.00	3.34	16.70	4.45
K7	8.09	11.69	5.57	6.68	20.04	5.21
K8	35.07	11.69	11.13	6.68	23.38	8.80
K9	6.78	11.69	5.57	2.23	16.70	4.30
K10	14.40	10.02	8.35	4.45	23.38	6.06
K11	20.22	11.69	11.13	6.68	21.71	7.14
					Total score	70.78
M1	20.33	11.69	11.13	6.68	21.71	7.15
M2	14.15	11.69	4.18	4.45	20.04	5.45
M3	16.17	11.69	10.02	6.68	26.72	7.13
					Total score	19.73
P1	7.68	8.35	6.26	3.34	19.09	4.47
P2	27.44	6.68	8.35	5.01	21.38	6.89
P3	26.72	6.68	0.00	5.01	19.09	5.75
P4	29.26	11.69	0.00	5.01	16.70	6.27
P5	30.06	11.69	8.35	5.01	20.99	7.61
P6	27.11	8.35	10.02	5.01	18.37	6.89
P7	20.12	6.68	8.35	5.01	20.04	6.02
P8	16.80	6.68	8.35	3.34	18.37	5.35
P9	19.21	10.02	8.35	4.45	17.18	5.92

Part	Part 1	Part 2	Part 3	Part 4	Part 5	Total score / 10
P10	22.24	11.69	4.18	5.01	13.36	5.65
P11	24.26	11.69	4.18	5.01	17.81	6.29
P12	21.95	2.34	8.35	5.01	21.71	5.94
P13	18.37	3.90	0.00	4.45	19.09	4.58
P14	29.87	3.90	0.00	4.45	19.59	5.78
P15	24.26	3.90	4.18	5.01	17.18	5.45
P16	21.34	8.35	3.34	4.45	16.70	5.42
P17	16.46	8.35	5.01	4.45	21.71	5.60
P18	22.59	8.35	10.02	4.45	20.04	6.55
P19	22.59	0.00	8.35	4.45	21.71	5.71
P20	21.34	3.90	0.00	4.45	20.04	4.97
P21	20.33	8.35	5.57	4.45	16.70	5.54
P22	20.33	3.90	12.53	4.45	21.71	6.29
P23	20.33	11.69	11.93	4.45	20.04	6.84
P24	22.59	6.68	11.13	5.01	20.04	6.55
P25	19.21	6.68	5.57	5.01	15.03	5.15
P26	26.28	11.69	5.57	5.01	18.37	6.69
P27	21.34	8.77	0.00	4.45	16.70	5.13
P28	16.46	0.00	3.34	4.45	16.70	4.10
P29	30.32	8.35	5.57	4.45	19.09	6.78
P30	26.28	11.69	13.92	6.68	18.37	7.69
P31	30.06	11.69	10.44	5.01	19.59	7.68
					Total score	185.55
PK1	30.32	11.69	16.70	6.68	16.70	8.21
PK2	8.09	5.01	8.35	1.67	10.02	3.31
PK3	4.80	11.69	8.35	4.45	10.02	3.93
PK4	14.40	11.69	10.44	4.45	15.03	5.60
PK5	22.24	11.69	8.35	6.68	11.69	6.06
PK6	22.24	10.02	13.92	5.01	16.70	6.79
PK7	16.17	8.35	8.35	3.34	13.36	4.96
PK8	2.74	3.90	0.00	4.45	8.35	1.94
PK9	0.00	8.35	5.57	4.45	10.02	2.84
PK10	16.46	11.69	8.35	5.01	16.70	5.82

Part	Part 1	Part 2	Part 3	Part 4	Part 5	Total score / 10
PK11	13.97	5.01	11.13	2.23	15.03	4.74
PK12	15.03	6.68	16.70	3.34	8.35	5.01
PK13	31.73	11.69	16.70	5.01	15.03	8.02
PK14	11.82	0.00	4.18	4.45	13.36	3.38
PK15	6.98	0.00	16.70	4.45	5.01	3.31
PK16	16.17	11.69	16.70	5.01	18.37	6.79
					Total score	80.71
S1	12.00	11.69	4.18	4.45	16.70	4.90
S2	26.72	11.69	11.13	6.68	26.72	8.29
S3	12.13	11.69	16.70	6.68	21.71	6.89
S4	31.73	11.69	16.70	5.01	16.70	8.18
S5	36.74	11.69	14.61	6.68	23.38	9.31
S6	11.69	11.69	16.70	6.68	15.03	6.18
S7	31.73	11.69	16.70	6.68	25.05	9.19
S8	35.07	11.69	16.70	6.68	26.72	9.69
S9	22.59	11.69	16.70	6.68	21.71	7.94
S10	20.33	2.34	16.70	6.68	23.38	6.94
S11	15.71	3.90	16.70	6.68	15.03	5.80
S12	36.66	11.69	16.70	6.68	21.71	9.34
S13	31.73	11.69	13.92	6.68	21.71	8.57
S14	26.28	11.69	15.03	6.68	26.72	8.64
S15	12.13	0.00	16.70	5.01	21.71	5.55
					Total score	115.41

Note: J: Johor; K: Kelantan; M: Melaka; P: Penang; Pk: Perak; S: Selangor